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The power of growth exhibited by ostrich ferns

GEORGE E. STONE

The power of growth exerted by plants is frequently so great that the work accomplished in some cases seems almost incredible. It is the purpose of this paper to give the results of some observations made by the writer relating to the power of growth in plants.

The writer has had for many years a number of ostrich ferns (*Onoclea Struthiopteris* Hoffm.) growing about his residence, where he has had an opportunity to observe them daily. These ferns have received the best of care and many of them have attained a very large size. Previous to planting them the beds in which they are growing were dug out to a depth of a few feet and filled with soil most suitable for their luxuriant development. Some of these beds are located close to the house, which has a border of tar concrete varying from 2½ to 5 feet in width. The ferns growing close to this border spread profusely and as the beds are rather limited in size the ferns frequently push their rhizomes under the concrete and the young frond stalks force themselves up through it. The concrete is composed of tar and coarse gravel mixed and rolled in the usual way, and has been laid for a number of years. It is from 2½ to 3 inches thick and exceptionally hard, and a heavy stroke from a sledge-hammer makes little or no impression upon it.

The rupturing of the concrete by the young frond shoots occurs almost yearly. Sometimes the concrete is ruptured where it joins the underpinning of the house, and again the ferns come up through the middle of the concrete. This occurs in the spring, when growth is active and when the fronds are unfolding. While those fronds which push themselves up through the concrete are necessarily more backward in unfolding than those not obstructed in their growth, it requires only a week or ten days, as a rule, for them to rupture the concrete, after which time they unfold quite rapidly. In one case, however, it required two years for a certain group of fronds to break through the concrete.

The ease with which this is accomplished and the relative freedom of the fronds from scars and injuries is remarkable when one takes into consideration the solidity of the concrete and the enormous power necessary for rupturing it.

Being interested in this phenomenon, we endeavored to ascertain approximately the power required to accomplish this rupturing; therefore we excavated a portion of the soil under the concrete and arranged a lever in such a manner that force could be applied in practically the same way as was done by the ferns; that is, a round piece of wood was placed on the end of the lever of the same dimensions as the undeveloped cluster of fern fronds. The fulcrum of the lever was 1 foot from the point of contact with the concrete, and weights were placed on the other end of the lever at different distances, as the case required. Our object in this test was to ascertain how long it would take to rupture the concrete and to determine the amount of weight necessary to do this. It was not intended to apply force enough to cause a rupturing of the concrete immediately, or even in a few hours, but to determine how much weight it would require to do this in ten to fifteen days; in other words, the same length of time as was usually required by the ferns to accomplish this. In this way we could obtain some idea of the force exerted by the fern fronds in breaking through the concrete.

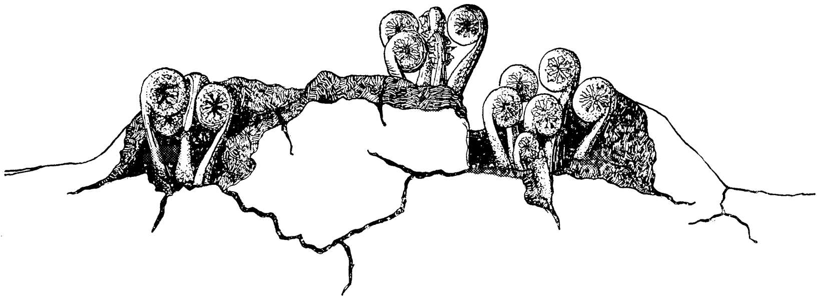

FIGURE 1. The rupturing of concrete by the young fronds of ostrich ferns (*Onoclea Struthiopteris* Hoffm.).

In one test, which we will designate no. 1, where the pressure exerted on the under surface of the concrete was equal to 699 pounds, rupturing occurred in a few hours. In another instance (test no. 2), where a weight of 264 pounds was applied, it required ten days to break through, and in still another (test no. 3) it required thirteen days for a weight of 189 pounds to produce the same effect on the concrete as that caused by the ferns. A few other tests were tried, but those given are typical of the results obtained.

In test no. 1, where a weight of 699 pounds was used and the concrete was ruptured in a few hours, the pressure applied exceeded that exerted by the ferns, and this is probably also true of test no. 2, in which a weight of 264 pounds was used, although in some instances this might not exceed the work done by the ferns. The force applied in test no. 3 was very similar, as regards length of time required and the manner of breaking through, to that actually accomplished by the ferns. This test, therefore, represents a fairly good duplication of what actually took place, and represents, at least in our estimation, the amount of force required to accomplish the same results shown by the ferns. If we take into consideration the average cross-section area of the frond shoots, which equals in one instance 39.15 square millimeters, we have, since there were six of these, 234 square millimeters as the total cross-section area of the frond shoots. In this test we found that the weight required was 189 pounds, or about 84,672 grams. This factor divided by the total area of the frond sections, or 234, equals 361 grams to each square millimeter of cross-section surface, or about 35 atmospheres. From the results of the various tests we are led to believe that this calculation is not an overestimate of the work actually accomplished by these ferns. Employing the same data for test no. 2, we would obtain a pressure of 49 atmospheres, which in our estimation, is somewhat in excess of the pressure actually exerted by the ferns. It should be pointed out, however, that tar concrete is much modified by temperature; at the same time the temperature was much higher at the time of the lever experiments than when the rupturing was done by the ferns, which occurred in April and May, while the experiments with the lever were done in May and June. The ferns were observed very closely during the time they were rupturing the concrete. This substance was so hard that after it had been pushed up it was impossible to make any impression upon the ragged edges except by the use of tools. The fern fronds, when pushed through the concrete, were practically unscarred in all cases and were normal in shape. The work was accomplished by a slow and constantly increasing pressure exerted on the under surface of the concrete.

There are many instances on record showing the great power exerted by plants when growth is restricted. It is well known that such restriction acts as a marked stimulus to the osmotic properties of the cells. Pfeffer* and others have measured the power of growth in various plant organisms, and in one instance Pfeffer records a longitudinal pressure equal to 24 atmospheres in the roots of *Zea Mays*, when encased in plaster of Paris. The writer has observed many instances where considerable power has been exerted by plants in overcoming difficulties. He has occasionally observed mushrooms breaking through tar concrete walks near dwellings, in which instance much power was exerted by these most delicately constructed plants. Cases are on record where flagstones have been dislocated by mushrooms which grew under them. We observed also in one instance a large dwelling house with one corner elevated a few inches above the others by the presence of elm roots under the foundation, and the dislocation of sidewalks, curbings, etc., by tree roots is a matter of common observation.

There are innumerable instances seen in mountainous regions where the roots of trees growing among ledges and boulders have moved large masses of rock. The writer has had under observation for many years a black birch tree, one of whose roots is continually elevating a large boulder. This particular tree has been growing in this situation for many years and one of the roots has entered a fissure in the boulder. This crack or fissure is at an angle of about 15 degrees, and where the root passes between the two halves of this boulder its vertical diameter is 4 or 5 inches, while its lateral diameter is 18 or 20 inches or more. Careful measurements of the dimensions of this boulder, together with specific gravity determinations, would indicate that the weight is about 18 tons, which is annually being lifted higher and higher by the root situated between the two halves.

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* "Druck und Arbeitsleistung durch wachsende Pflanzen," 1893.

The experiments made some years ago by Clark, at the Massachusetts Agricultural College, in harnessing a squash, showed that it was capable of growing and developing under a weight of 5,000 pounds, but from data obtained in this experiment it would appear that there were not more than two or three atmospheres developed in the cells, and hence not remarkable from the point of view of pressure exerted by the cells. The average pressure exerted by ordinary growing cells is from one to three atmospheres, but by resorting to stimulation this pressure may be enormously increased and may even exceed one hundred atmospheres, as in the case of moulds growing in concentrated solutions.